

CLAIMS

What is claimed is:

1. A refrigerator having a compressor for compressing a coolant, a radiator for radiating heat from the coolant, a flow control valve for regulating the flow volume of the coolant, and an evaporator for evaporating the coolant, characterized in that the refrigerator includes:

a coolant cooling means for cooling the coolant; and

a heat-exchange-amount control means for controlling the amount of heat exchanged in the coolant cooling means; wherein

the coolant is circulated through the compressor, the radiator, the coolant cooling means, the flow control valve, and the evaporator, in that sequence.

2. A refrigerator as recited in claim 1, utilizing a nonflammable coolant whose global warming potential is lower than that of chlorofluorocarbon, wherein the coolant cooling means includes:

a second compressor for compressing a second coolant whose energy consumption efficiency is higher than that of the coolant;

a condenser for radiating heat from the second coolant;

a second flow control valve for regulating the flow volume of the second coolant; and

a second evaporator for evaporating, by means of heat from the coolant, the second coolant; wherein

the second coolant is circulated through the second compressor, the condenser, the second flow control valve, and the second evaporator, in that sequence.

3. A refrigerator as recited in claim 1, the compressor having an intermediary-pressure inlet for drawing in the coolant during compressing, the refrigerator further comprising:

a gas-liquid separator for separating into gas and liquid the coolant as

1 outputted from the flow control valve;

2 a bypass pipe for introducing into the intermediary-pressure inlet part or all of
3 the coolant gas separated by the gas-liquid separator; and

4 a third flow control valve for regulating the flow volume of the coolant as
5 outputted from the gas-liquid separator and inputted into the evaporator.

6
7 4. A refrigerator as recited in claim 1, further comprising:

8 a third compressor for compressing the coolant as compressed by the
9 compressor;

10 a gas-liquid separator for separating into gas and liquid the coolant as
11 outputted from the flow control valve;

12 a bypass pipe for introducing into the third compressor part or all of the
13 coolant gas separated by the gas-liquid separator; and

14 a third flow control valve for regulating the flow volume of the coolant as
15 outputted from the gas-liquid separator and inputted into the evaporator; wherein

16 the coolant as outputted from the third compressor is inputted into the
17 radiator.

18
19 5. A refrigerator as recited in claim 1, further comprising:

20 a third radiator for radiating heat from the coolant as outputted from the
21 compressor; and

22 a third compressor for compressing the coolant in a state in which heat of the
23 coolant has been radiated away by the third radiator; wherein

24 the coolant is flowed through the third radiator, the third compressor, and the
25 radiator, in that sequence.

26
27 6. A refrigerator as recited in claim 2, further comprising:

28 a third compressor for compressing the coolant as compressed by the
29 compressor; and

30 a third heat exchanger for exchanging heat between the coolant and the

1 second coolant; wherein

2 the coolant as outputted from the compressor is flowed through the third heat
3 exchanger, the third compressor, and the radiator, in that sequence, and

4 the second coolant as outputted from the second evaporator is flowed through
5 the third heat exchanger, and the second compressor, in that sequence.

6
7 7. A refrigerator as recited in claim 2, further comprising:

8 a third compressor for compressing the coolant as compressed by the
9 compressor;

10 a third heat exchanger for exchanging heat between the coolant and the
11 second coolant; and

12 a forth flow control valve for regulating the flow volume of the second coolant
13 flowing in the third heat exchanger; wherein

14 the coolant as outputted from the compressor is flowed through the third heat
15 exchanger, the third compressor, and the radiator, in that sequence, and

16 part of the second coolant as outputted from the condenser is flowed through
17 the forth flow control valve, the third heat exchanger, and the second compressor, in
18 that sequence.

19
20 8. A refrigerator as recited in claim 1, wherein the heat-exchange-amount control
21 means includes:

22 a drying-ratio estimation means for estimating, by a measured value using a
23 predetermined sensor, a drying ratio that is a ratio between a drying rate of the
24 coolant at the exit of the flow control valve and a drying rate when the coolant at the
25 exit of the radiator is decompressed to its evaporation temperature;

26 a drying-ratio control-range determination means for determining a control
27 range of the drying ratio, so that a COP value is obtained, in which the difference
28 between the value and the maximum value obtained when the drying ratio is varied
29 under predetermined operational conditions is within a predetermined range; and

30 a control means for controlling the amount of heat exchanged in the coolant

1 cooling means, so that the drying ratio estimated by the drying-ratio estimation means
2 is within the control range.

3
4 9. A refrigerator as recited in claim 2, wherein the heat-exchange-amount control
5 means includes:

6 a drying-ratio estimation means for estimating, by a measured value using a
7 predetermined sensor, a drying ratio that is a ratio between a drying rate of the
8 coolant at the exit of the flow control valve and a drying rate when the coolant at the
9 exit of the radiator is decompressed to its evaporation temperature;

10 a drying-ratio control-range determination means for determining a control
11 range of the drying ratio, so that a COP value is obtained, in which the difference
12 between the value and the maximum value obtained when the drying ratio is varied
13 under predetermined operational conditions is within a predetermined range; and

14 a control means for controlling the flow volume of the second coolant flowing
15 in the coolant cooling means, so that the drying ratio estimated by the drying-ratio
16 estimation means is within the control range.

17
18 10. A refrigerator as recited in either claim 8 or claim 9, wherein the predetermined
19 sensor includes:

20 at least one of a first pressure-measuring means for measuring pressure of the
21 coolant between the exit of the flow control valve and the entrance of the evaporator,
22 and a first temperature-measuring means for measuring temperature of the coolant at
23 the exit of the flow control valve;

24 a second pressure-measuring means for measuring pressure of the coolant
25 between the compressor and the flow control valve;

26 a second temperature-measuring means for measuring temperature of the
27 coolant at the entrance of the flow control valve; and

28 a third temperature-measuring means for measuring temperature of the
29 coolant at the exit of the radiator.

1 11. A refrigerator as recited in either claim 8 or claim 9, wherein the predetermined
2 sensor includes:

3 a first temperature-measuring means for measuring temperature of the
4 coolant at the exit of the flow control valve;

5 a second temperature-measuring means for measuring temperature of the
6 coolant at the entrance of the flow control valve;

7 a third temperature-measuring means for measuring temperature of the
8 coolant at the exit of the radiator;

9 a forth temperature-measuring means for measuring temperature of the
10 coolant at the entrance of the radiator; and

11 a fifth temperature-measuring means for measuring temperature of the
12 coolant at the entrance of the compressor.

13
14 12. A refrigerator as recited in claim 1, further comprising:

15 a second temperature-measuring means for measuring flow-control-valve
16 entrance temperature as coolant temperature at the entrance of the flow control valve;
17 wherein the heat-exchange-amount control means includes:

18 a flow-control-valve-entrance-temperature control-range determination means
19 for determining a control range of the flow-control-valve entrance temperature, so that
20 a COP value is obtained, in which the difference between the value and the maximum
21 value obtained when the flow-control-valve entrance temperature is varied under
22 predetermined operational conditions is within a predetermined range; and

23 a control means for controlling the amount of heat exchanged in the coolant
24 cooling means, so that the coolant temperature measured by the second
25 temperature-measuring means is within the control range.

26
27 13. A refrigerator as recited in claim 2, further comprising:

28 a second temperature-measuring means for measuring flow-control-valve
29 entrance temperature as coolant temperature at the entrance of the flow control valve;
30 wherein the heat-exchange-amount control means includes:

1 a flow-control-valve-entrance-temperature control-range determination means
2 for determining a control range of the flow-control-valve entrance temperature, so that
3 a COP value is obtained, in which the difference between the value and the maximum
4 value obtained when the flow-control-valve entrance temperature is varied under
5 predetermined operational conditions is within a predetermined range; and

6 a control means for controlling the flow volume of the second coolant flowing
7 in the coolant cooling means, so that the coolant temperature measured by the second
8 temperature-measuring means is within the control range.

9
10 14. A refrigerator as recited in claim 1, further comprising:

11 a third temperature-measuring means for measuring coolant temperature at
12 the exit of the radiator; wherein the heat-exchange-amount control means includes:

13 a flow-control-valve-entrance-temperature estimation means for estimating,
14 by the temperature measured by the third temperature-measuring means and the
15 amount of heat exchanged in the coolant cooling means, flow-control-valve entrance
16 temperature as coolant temperature at the entrance of the flow control valve;

17 a flow-control-valve-entrance-temperature control-range determination means
18 for determining a control range of the flow-control-valve entrance temperature, so that
19 a COP value is obtained, in which the difference between the value and the maximum
20 value obtained when the flow-control-valve entrance temperature is varied under
21 predetermined operational conditions is within a predetermined range; and

22 a control means for controlling the amount of heat exchanged in the coolant
23 cooling means, so that the flow-control-valve entrance temperature estimated by the
24 flow-control-valve-entrance-temperature estimation means is within the control range.

25
26 15. A refrigerator as recited in claim 2, further comprising:

27 a third temperature-measuring means for measuring coolant temperature at
28 the exit of the radiator; wherein the heat-exchange-amount control means includes:

29 a flow-control-valve-entrance-temperature estimation means for estimating,
30 by the temperature measured by the third temperature-measuring means and the

1 amount of heat exchanged in the coolant cooling means, temperature at the entrance
2 of the flow control valve as coolant temperature at the entrance of the flow control
3 valve;

4 a flow-control-valve-entrance-temperature control-range determination means
5 for determining a control range of the flow-control-valve entrance temperature, so that
6 a COP value is obtained, in which the difference between the value and the maximum
7 value obtained when the flow-control-valve entrance temperature is varied under
8 predetermined operational conditions is within a predetermined range; and

9 a control means for controlling the flow volume of the second coolant flowing
10 in the coolant cooling means, so that the flow-control-valve entrance temperature
11 estimated by the flow-control-valve-entrance-temperature estimation means is within
12 the control range.

13
14 16. A refrigerator as recited in either claim 8 or claim 9, further comprising:

15 at least either a first pressure-measuring means for measuring pressure of the
16 coolant between the exit of the flow control valve and the entrance of the evaporator, or
17 a first temperature-measuring means for measuring temperature of the coolant at the
18 exit of the flow control valve; wherein

19 the drying-ratio control-range determination means determines a control
20 range of the drying ratio, using either the coolant pressure measured by the first
21 pressure-measuring means or the coolant temperature measured by the first
22 temperature-measuring means.

23
24 17. A refrigerator as recited in either claim 8 or claim 9, further comprising:

25 a second pressure-measuring means for measuring pressure of the coolant
26 between the exit of the radiator and the entrance of the flow control valve; wherein

27 the drying-ratio control-range determination means determines a control
28 range of the drying ratio, using the coolant pressure measured by the second
29 pressure-measuring means.

1 18. A refrigerator as recited in any one of claims 14 to 17, further comprising:
2 at least one of the first pressure-measuring means for measuring pressure of
3 the coolant between the exit of the flow control valve and the entrance of the
4 evaporator, and the first temperature-measuring means for measuring temperature of
5 the coolant at the exit of the flow control valve; wherein

6 the flow-control-valve-entrance-temperature control-range determination
7 means determines a control range of the temperature at the entrance of the flow
8 control valve, using either the coolant pressure measured by the first
9 pressure-measuring means or the coolant temperature measured by the first
10 temperature-measuring means.

11
12 19. A refrigerator as recited in any one of claims 14 to 17, further comprising:

13 a second pressure-measuring means for measuring pressure of the coolant
14 between the exit of the radiator and the entrance of the flow control valve; wherein

15 the flow-control-valve-entrance-temperature control-range determination
16 means determines a control range of the temperature at the entrance of the flow
17 control valve, using the coolant pressure measured by the second pressure-measuring
18 means.

19
20 20. An air conditioner having a compressor for compressing a coolant, a four-way valve
21 for switching the direction in which the coolant as outputted from the compressor
22 flows, an outdoor heat exchanger for exchanging heat between the coolant and outdoor
23 air, a flow control valve for regulating the flow volume of the coolant, and an indoor
24 heat exchanger for exchanging heat between the coolant and indoor air, characterized
25 in that the air conditioner includes:

26 a coolant cooling/heating means for cooling as well as heating the coolant; and
27 a heat-exchange-amount control means for controlling the amount of heat
28 exchanged in the coolant cooling/heating means; wherein

29 when the air conditioner is being operated for cooling, the coolant is circulated
30 through the compressor, the outdoor heat exchanger, the coolant cooling/heating

means, the flow control valve, and the indoor heat exchanger, in that sequence, and
when the air conditioner is being operated for warming, the coolant is
circulated through the compressor, the indoor heat exchanger, the flow control valve,
the coolant cooling/heating means, and the outdoor heat exchanger, in that sequence.

21. An air conditioner as recited in claim 20, utilizing a nonflammable coolant whose
global warming potential is lower than that of chlorofluorocarbon, wherein the coolant
cooling/heating means includes:

a second compressor for compressing a second coolant whose energy
consumption efficiency is higher than that of the coolant;

a second four-way valve for switching the direction in which the second coolant
as outputted from the second compressor flows;

a first heat exchanger for exchanging heat between the second coolant and
outdoor air;

a second flow control valve for regulating the flow volume of the second
coolant; and

a second heat exchanger for exchanging heat between the coolant and the
second coolant; wherein

when the air conditioner is being operated for cooling, the second coolant is
circulated through the second compressor, the first heat exchanger, the second flow
control valve, and the second heat exchanger, in that sequence, and

when the air conditioner is being operated for warming, the second coolant is
circulated through the second compressor, the second heat exchanger, the second flow
control valve, and the first heat exchanger, in that sequence.

22. An air conditioner as recited in claim 20, the compressor having an
intermediary-pressure inlet for drawing in the coolant during compressing, the air
conditioner further comprising:

a third flow control valve for regulating the flow volume of the coolant
inputting into and outputting from the indoor heat exchanger;

1 a gas-liquid separator for separating into gas and liquid the coolant; and
2 a bypass pipe for introducing into the intermediary-pressure inlet part or all of
3 the coolant gas separated by the gas-liquid separator; wherein
4 when the air conditioner is being operated for cooling, the coolant is circulated
5 through the flow control valve, the gas-liquid separator, the third flow control valve,
6 and the indoor heat exchanger, in that sequence, and
7 when the air conditioner is being operated for warming, the coolant is
8 circulated through the indoor heat exchanger, the third flow control valve, the
9 gas-liquid separator, and the flow control valve, in that sequence.

10
11 23. An air conditioner as recited in claim 20, further comprising:

12 a third compressor for compressing the coolant as compressed by the
13 compressor;

14 a third flow control valve for regulating the flow volume of the coolant
15 inputting into and outputting from the indoor heat exchanger;

16 a gas-liquid separator for separating into gas and liquid the coolant; and

17 a bypass pipe for introducing into the third compressor part or all of the
18 coolant gas separated by the gas-liquid separator; wherein:

19 the coolant as outputted from the third compressor is inputted into the
20 four-way valve, and

21 when the air conditioner is being operated for cooling, the coolant is flowed
22 through the flow control valve, the gas-liquid separator, the third flow control valve,
23 and the indoor heat exchanger, in that sequence, meanwhile, when the air conditioner
24 is being operated for warming, the coolant is flowed through the indoor heat exchanger,
25 the third flow control valve, the gas-liquid separator, and the flow control valve, in that
26 sequence.

27
28 24. An air conditioner as recited in claim 20, further comprising:

29 a third radiator for radiating heat from the coolant as outputted from the
30 compressor; and

1 a third compressor for compressing the coolant in a state in which heat of the
2 coolant has been radiated away by the third radiator; and

3 a flow-route changing means for inputting into the third radiator the coolant
4 as outputted from the compressor when the air conditioner is being operated for
5 cooling, and for inputting into the third compressor when the air conditioner is being
6 operated for warming.

7
8 25. An air conditioner as recited in claim 21, further comprising:

9 a third compressor for compressing the coolant as compressed by the
10 compressor;

11 a third heat exchanger for exchanging heat between the coolant and the
12 second coolant; and

13 a flow-route changing means for flowing the coolant as outputted from the
14 compressor through the third heat exchanger and the third compressor, in that
15 sequence, when the air conditioner is being operated for cooling, and into the third
16 compressor when the air conditioner is being operated for warming; wherein

17 the coolant as outputted from the third compressor is inputted into the
18 four-way valve, and the second coolant as outputted from the second heat exchanger is
19 flowed through the third heat exchanger and the second compressor, in that sequence.

20
21 26. An air conditioner as recited in claim 21, further comprising:

22 a third compressor for compressing the coolant as compressed by the
23 compressor;

24 a third heat exchanger for exchanging heat between the coolant and the
25 second coolant; and

26 a forth flow control valve for regulating the flow volume of the second coolant
27 flowing in the third heat exchanger; wherein

28 the coolant as outputted from the compressor is flowed through the third heat
29 exchanger, the third compressor, and the four-way valve, in that sequence, and

30 part of the second coolant as outputted from the first heat exchanger is flowed

- 1 through the forth flow control valve, the third heat exchanger, and the second
- 2 compressor, in that sequence.